

## 1 CLAIMS

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3 1) A frequency stabilisation apparatus for stabilising a  
4 frequency output of a laser cavity, the frequency  
5 stabilisation apparatus comprising an intracavity  
6 birefringent etalon, wherein the intracavity  
7 birefringent etalon is employed to derive a polarised  
8 electric field component from an intracavity electric  
9 field of the laser cavity, the orientation of  
10 polarisation of the polarised electric field  
11 component being dependent on the frequency and  
12 polarisation of the intracavity electric field.

13

14 2) A frequency stabilisation apparatus as claimed in  
15 Claim 1 wherein the intracavity birefringent etalon  
16 acts as a first quarter waveplate on the polarised  
17 electric field component such that when the frequency  
18 of the intracavity electric field corresponds to a  
19 resonant frequency of the birefringent etalon the  
20 polarised electric field component is linearly  
21 polarised.

22

23 3) A frequency stabilisation apparatus as claimed in  
24 Claim 1 or Claim 2 wherein the frequency  
25 stabilisation apparatus further comprises a second  
26 quarter waveplate.

27

28 4) A frequency stabilisation apparatus as claimed in  
29 Claim 3 wherein the frequency stabilisation apparatus  
30 further comprises an elliptical polarisation analyser  
31 for analysing the state of polarisation of the  
32 polarised electric field component on being  
33 transmitted through the second quarter waveplate.

- 1  
2 5) A frequency stabilisation apparatus as claimed in  
3 Claim 4 or Claim 5 wherein an optical axis of the  
4 second quarter waveplate is aligned with an optical  
5 axis of the birefringent etalon such that on being  
6 transmitted through the second quarter waveplate the  
7 polarised electric field component is linearly  
8 polarised, the plane of linear polarisation being  
9 dependent on the frequency of the intracavity  
10 electric field relative to the resonant frequency of  
11 the birefringent etalon.  
12
- 13 6) A frequency stabilisation apparatus as claimed in  
14 Claim 4 or Claim 5 wherein an optical axis of the  
15 second quarter waveplate is aligned at 45° relative  
16 to an optical axis of the birefringent etalon such  
17 that on being transmitted through the second quarter  
18 waveplate the polarised electric field component of  
19 an off resonance frequency is linearly polarised, the  
20 plane of linear polarisation being dependent on the  
21 frequency of the intracavity electric field relative  
22 to the resonant frequency of the birefringent etalon.  
23
- 24 7) A frequency stabilisation apparatus as claimed in any  
25 of Claims 4 to 6 wherein the elliptical polarisation  
26 analyser comprises a polarisation dependent  
27 beamsplitter and two light detecting means wherein  
28 the polarisation dependent beamsplitter is orientated  
29 so as to resolve the polarised electric field  
30 component into two spatially separated components  
31 each of which is incident on one of the light  
32 detecting means.  
33

1 8) A frequency stabilisation apparatus as claimed in  
2 Claim 7 wherein the elliptical polarisation analyser  
3 further comprises an electronic circuit wherein the  
4 electronic circuit derives an error signal from  
5 electrical output signals generated by the two light  
6 detecting means.

7  
8 9) A frequency stabilisation apparatus as claimed in  
9 Claim 8 wherein the electronic circuit further  
10 comprises a feedback circuit for generating a  
11 feedback signal in response to the error signal so as  
12 to control the orientation of the birefringent etalon  
13 within the intracavity electric field in order to  
14 minimise the magnitude of the error signal.

15  
16 10) A frequency scanning apparatus for scanning a  
17 frequency output of a laser cavity comprising a  
18 frequency stabilising apparatus as claimed in any of  
19 Claims 1 to 9 and a cavity length adjuster that  
20 provides a means for scanning a length of the laser  
21 cavity.

22  
23 11) A frequency scanning apparatus as claimed in Claim 10  
24 wherein the cavity length adjuster comprises at least  
25 one laser cavity mirror mounted on a piezoelectric  
26 crystal.

27  
28 12) A method for stabilising a frequency output of a  
29 laser cavity comprising the steps of:

30 1) Employing a birefringent etalon to sample an  
31 intracavity electric field of the laser cavity so  
32 as to derive a polarised electric field component  
33 whose polarisation is dependent on the polarisation

1           and frequency of the intracavity electric field  
2           relative to a resonant frequency of the  
3           birefringent etalon;

4           2) Deriving an error signal from the polarised field  
5           component; and

6           3) Stabilising the birefringent etalon to the derived  
7           error signal.

8

9    13) A method as claimed in Claim 12 wherein the polarised  
10       electric field component is linearly polarised when  
11       the intracavity electric field corresponds to a  
12       resonant frequency of the birefringent etalon.

13

14   14) A method as claimed in Claim 12 or Claim 13 wherein  
15       the polarised electric field component is  
16       elliptically polarised when the intracavity electric  
17       field corresponds to a non-resonant frequency of the  
18       birefringent etalon.

19

20   15) A method as claimed in Claim 14 wherein the helicity  
21       of the polarised electric field component is of an  
22       alternative sign when the intracavity electric field  
23       frequency is above or below the resonant frequency of  
24       the birefringent etalon.

25

26   16) A method as claimed in any of Claims 12 to 15 wherein  
27       the step of deriving the error signal comprises the  
28       steps of:

29       1) Introducing a  $\pi/2$  phase shift to the orthogonal  
30       constituent components of the polarised electric  
31       field component;

32       2) Resolving the orthogonal constituent components of  
33       the polarised electric field component; and

- 1        3) Calculating an intensity ratio signal the  
2        orthogonal constituent components of the polarised  
3        electric field component.  
4
- 5    17) A method as claimed in Claim 16 wherein the step of  
6        introducing the  $\pi/2$  phase shift to the orthogonal  
7        constituent components of the polarised electric  
8        field component results in the plane of polarisation  
9        of the polarised electric field component being  
10       directly dependent on the frequency of the  
11       intracavity electric field relative to the resonant  
12       frequency of the birefringent etalon.  
13
- 14    18) A method as claimed in any of claims 12 to 17 wherein  
15       the birefringent etalon is stabilised to the derived  
16       error signal by controlling the orientation of the  
17       birefringent etalon within the intracavity electric  
18       field in order to minimise the magnitude of the error  
19       signal.  
20
- 21    19) A method for scanning a frequency output of a laser  
22       cavity comprising:  
23       1) Stabilising the frequency output of the laser  
24       cavity in accordance with the method of any of  
25       Claims 12 to 18;  
26       2) Scanning an optical length of the laser cavity; and  
27       3) Scanning the orientation of the birefringent etalon  
28       within the intracavity electric field in order to  
29       track the scanned optical length of the laser  
30       cavity.